Studies of the AMANDA PMT and 100 M-Ohm active base at cold temperatures

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Setup

The dark box has been modified to include a penetration for a hose/pipe that is connected on the outside of the freezer (room temperature) to the LED. This was done to avoid the instabilities (signal disappearing or changes too rapidly) that were observed when the LED/Pulser was cooled inside the dark box.

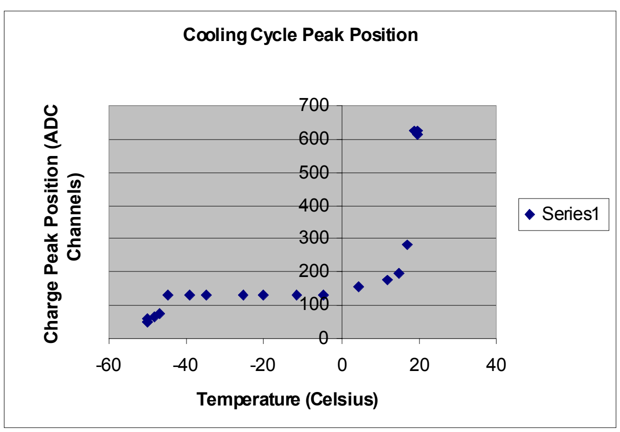
Three new desiccants were installed in the dark box before sealing to avoid moisture-related effect.

In the dark box, we look at the LED light coming from the hose using the Amanda Tube with the active 100 Mega-Ohm base and the transformer coupling. We set the total high voltage to 1000 V (270 V from the cathode to the first dynode and 730 V from the first dynode to the cathode). As in previous runs at this gain, the pulse peak from a SPE on a 93 Ohm terminator is 12mV.

Cooling Cycle

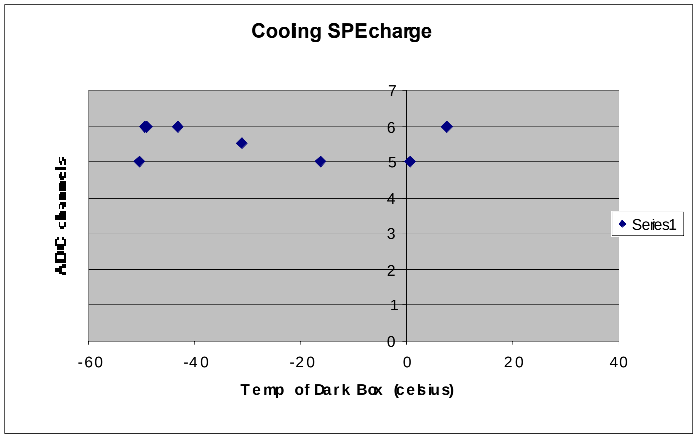
Using the LN_2-freezer, we lowered the temperature and made measurements of the position of the total-charge peak-position as a function of temperature at two pulser voltages: 12.6 V and 6.3 V. The first voltage produced about 100 photoelectrons (at the beginning of the measurement at room temperature). The second produced mostly pedestal (empty) events and some SPE's.

The graph below shows the value of the charge as a function of the temperature for the 12.6 V setting:

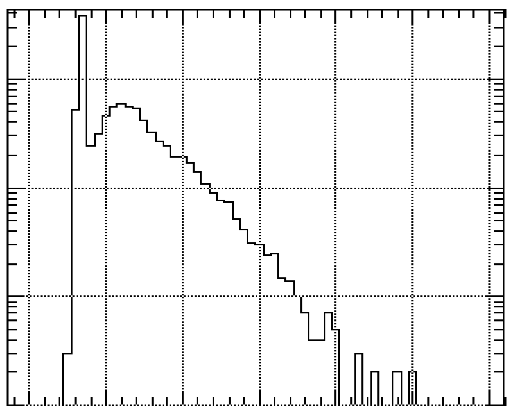


As seen in the graph, the total output signal varies by about a factor of 20 from room temperature to –50 C. This variation is due to the change in the amount of light reaching the photocathode. In the current setup, light travels by reflection on the internal surface of the hose. As water condenses on the cooled hose, less light gets reflected.

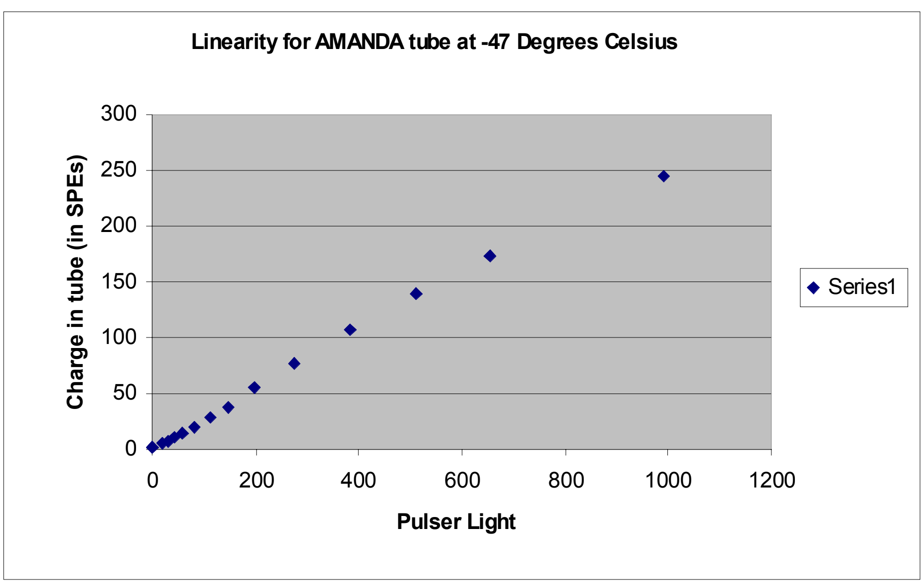
In order to prove that the effect seen above is NOT due to a drastic change in gain or some other base problem, the following graph shows the position of the SPE peak (pedestal subtracted):



The SPE gain shows a maximum variation of 20%, with no clear temperature dependence. The scatter is due to the fact that peak positions were obtained "by eye" (not a rigorous mean over bins) and to the coarseness of the binning for determining the pedestal. Below is a typical SPE charge spectrum (on a log plot) with pedestal from which the SPE peak positions is extracted.



Linearity at Low Temperature

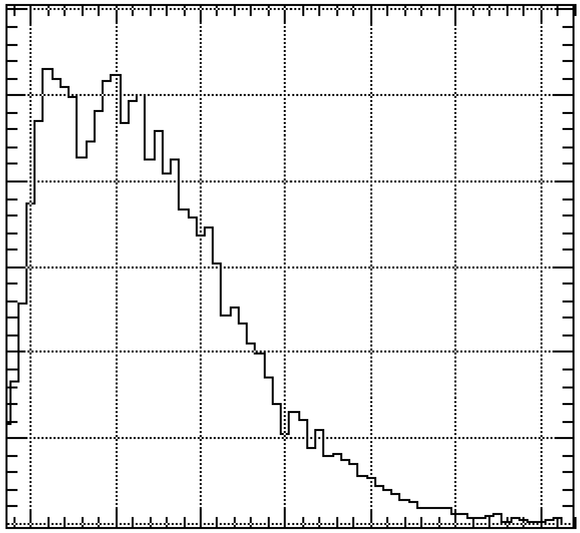


With the system kept at –47 C, linearity was studied by varying the pulser voltage. The plot above shows the charge in SPE's vs. the pulser light intensity, which is proportional to

$$\left(V - V_0\right)^2.$$

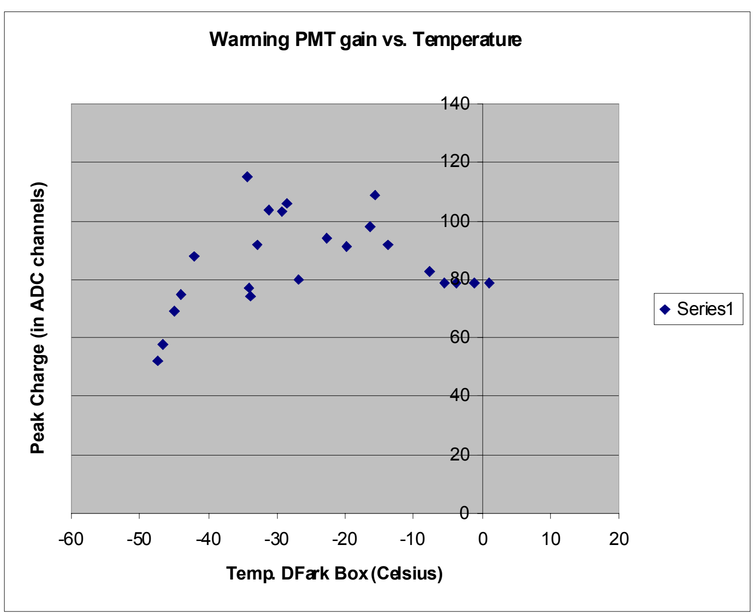
The last point to the right corresponds to the maximum power supply voltage. One expects flattening of the response for higher photon multiplicities.

For a 9.9 V pulser setting we obtained a nice separation between one and two photoelectrons:



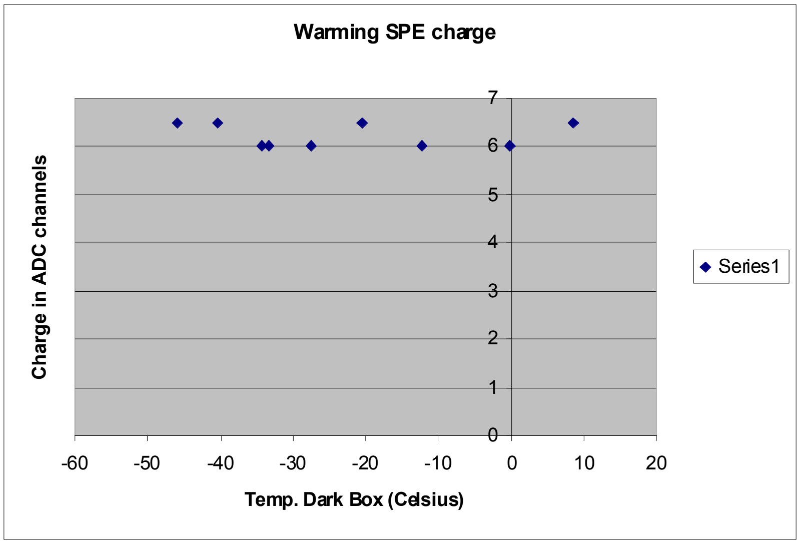
Warming Cycle

Finally, we let the system warm back to room temperature; again measuring the charge peaks at 12.6 and 6.3 V. The 12 V collected charge is shown below, where again we see large variations due to changes in the number of photons getting to the photocathode:



Again, we plot the SPE peak position to demonstrate that there is no gain change to within 20%:

After the box was warmed, we looked for condensation. There was no sign of water inside the dark box. The desiccant did change color a little. However, it was not saturated. When we looked at the light tube, we noticed a significant amount of water in the tube.



Conclusions

- The Amanda tube and the 100 Mega-Ohm base perform well at low temperatures up to –50 C.
- Gain variations in the range between room temperature and –50 C are less than 20%.
- At low temperature (-50 C) the base/tube are linear (at 1000 V) up to 100-200 photoelectrons.
- The system is probably changing its gain by less than the stated 20% but better measurements would require an amplifier to make better use of the charge sensitivity of the integrating ADC.
- The system, as is, is appropriate for testing the DOM electronic boards, but improvements in the way the light enters the dark boxes would ease/improve the measurement.